408/89

CENTURY-DETROIT

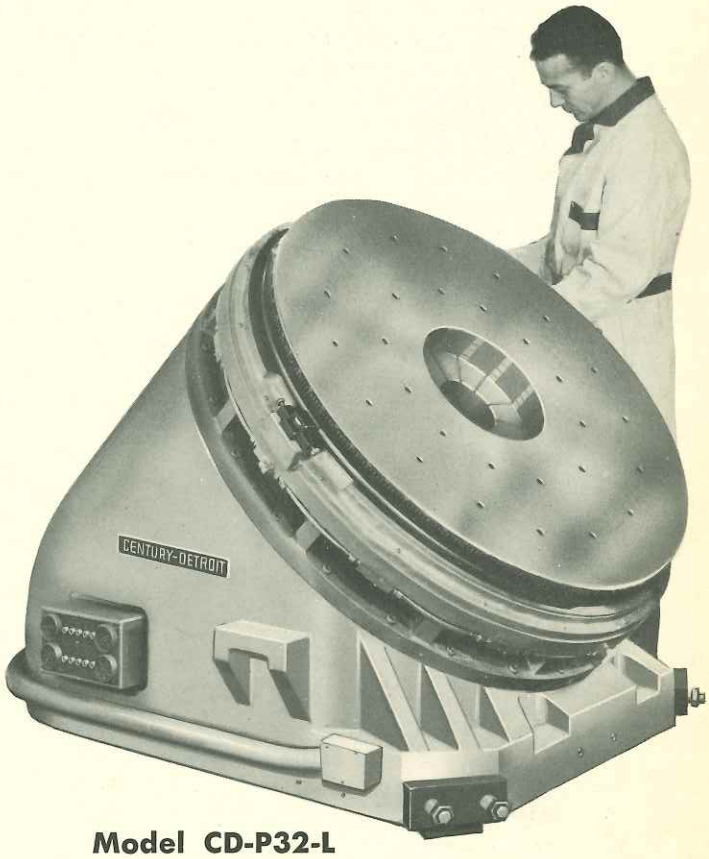
CORPORATION

ULTRA-PRECISION HEAVY-DUTY HYDROSTATIC RATE TABLES

POLAR AND VERTICALLY ORIENTED WITH 2nd AXIS CONVERTIBILITY

To fill the need for a very precise, mechanically stable, fixed orientation rate table, Century-Detroit has modified its proven, well-known, and highly satisfactory 2-axis systems, in two sizes, by substituting a flat platen for the inner gimbal stanchion member. The result, shown in the small polar-oriented table below, is an axis of unparalleled precision, with load capacity and servo performance of a very high order.

- **HYDROSTATIC BEARING**
- **EXTREME PRECISION OF PLANE AND AXIS OF ROTATION**
- **CAN BE CONVERTED TO 2-AXIS SYSTEM**
- **TREMENDOUS LOAD CAPACITY**
- **PERFORMANCE IS STABLE FOR VERY LONG PERIODS OF TIME**



Model CD-P32-L

CONFIGURATIONS

This series of single-axis, ultra-precise rate tables has four basic members; a 60″ vertical-axis unit, a 36″ vertical-axis unit, a 60″ polar-oriented family of tables, and a 36″ polar-oriented family. Since the intent of this design places the primary emphasis on axial precision and long-term stability, the tables are built with fixed latitude angles, which can be selected for anywhere in the U.S., Canada, or Western Europe.

PERFORMANCE

Planar Wobble: ± 0.3 sec. for polar units.
± 0.2 sec. for vertical units.

Axial Eccentricity: 0.000030″ T.I.R.

Rate Accuracy — Short Term: ± 1 sec. excursion.

Rate Accuracy — Long Term: ± 1.5 sec./hr.

Readout Accuracy: ± 1 sec. repeatable to ± 0.2 sec.

SECOND-AXIS CONVERSION

Since the design of these tables is based directly on the 2-axis systems, they can, should the need arise, be converted to 2-axis units by a very straightforward factory modification. This consists of replacing the top platen with a stanchion, inserting an inner gimbal, adding a hydrostatic fluid coupling (on a pad already provided in the casting) and running the wiring up to the inner gimbal slip rings. Since the inner gimbal has variable attitude, its hydrostatic bearings must be vacuum drained, so that a new hydraulic power unit is required. The result is a perfectly conventional Century-Detroit 2-axis system, indistinguishable in appearance and performance from one originally built as a 2-axis.

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BASE ASSEMBLY

In line with the essential requirement of maximum long-term dimensional and structural stability, the base unit is an extremely heavy-duty casting, extensively ribbed in critical areas to provide large cross sections in all areas of potential flexure. No attempt to trade strength for saving in weight has been made — rugged construction is primary in this series of tables.

The base is supported on three inclined-plane, self-locking leveling pads, with ± ½° range of adjustment in both elevation and azimuth angles. Catspaw serrated treads are provided, and the rim of the base is grooved so that the base can be grouted into place after leveling. Leveling and azimuth setting can easily be made to within ± 1 sec. by these adjustments. Cast pads are provided for 2 bubble levels on the external surface and for a fluid coupling on the inner base aligned to the axis for later use in 2-axis conversion.

LATITUDE SELECTION (Polar Tables)

Gyro testing on these tables can be performed at any fixed latitude from 28° N. to 49° N. However, in order to minimize instability in the polar angle setting, the base is, in each case, a one-piece unit. Thus, the polar angle at which the table is to be used must be specified at the time of purchase. If, at a later time, the table must be moved to a new location, the base unit can be exchanged.

TABLE TOP AND CLAMP

The table top is also the upper thrust plate of the bearing and is sufficiently heavy so that the internal hydrostatic forces will not flex it. It is provided with an engraved scale on the periphery and an integral clamp ring, engaged by a floating-fixed clamp and dual micrometer adjustment. Angular adjustment to the limit of resolution of the readout can be made. A drilled and tapped hole pattern in the table top is standard, but can be modified to suit specific requirements.

A large recess is provided at the center for electrical connections from the slip rings.

MATERIAL AND WORKMANSHIP

The material is close-grain fully stabilized cast Meehanite, employed throughout the industry for the best possible long-term dimensional stability. The workmanship is good laboratory quality; all exterior cast surfaces are filled and painted, all machined surfaces are plated or protected, and all operating handles chromed or anodized.

HYDROSTATIC BEARING

The heart of the tables is Century-Detroit's patented hydrostatic radial-thrust bearing, which consists of a housing into which the pressure pockets are machined, an upper thrust plate (which is also the table top), a journal and a lower thrust plate. Oil from the hydraulic power unit is manifolded to each of three rings of capillary metering subassemblies, one on each active bearing face. Each capillary restrictor element is removable for cleaning, and each metering sub-assembly has a pressure gage to monitor pocket pressure.

Oil is gravity drained into a return manifold which feeds a booster pump to return it to the hydraulic power unit. Special precautions, including the use of frictionless labyrinth seals and special materials are used to produce a completely leak-free system. The return oil piping and manifold are only vented through a capillary seal, so that an active collector system can be added if the 2-axis conversion is desired.

AXIS COMPONENTS

The axis is driven by a 22 ft.-lb. bearingless dc torque motor. A tachometer of the same type is also provided, so as to have a rate stabilizing signal available. Inductosyn plates are mounted on the axis, also without bearings, for use with the Table Tracking Inductosyn and also for use as a table angle indicator and mark generator. Provisions are made for adjustment and alignment of the Inductosyn plates, and for rotation of one set to synchronize with the absolute table angle indicated by the scale on the table periphery.

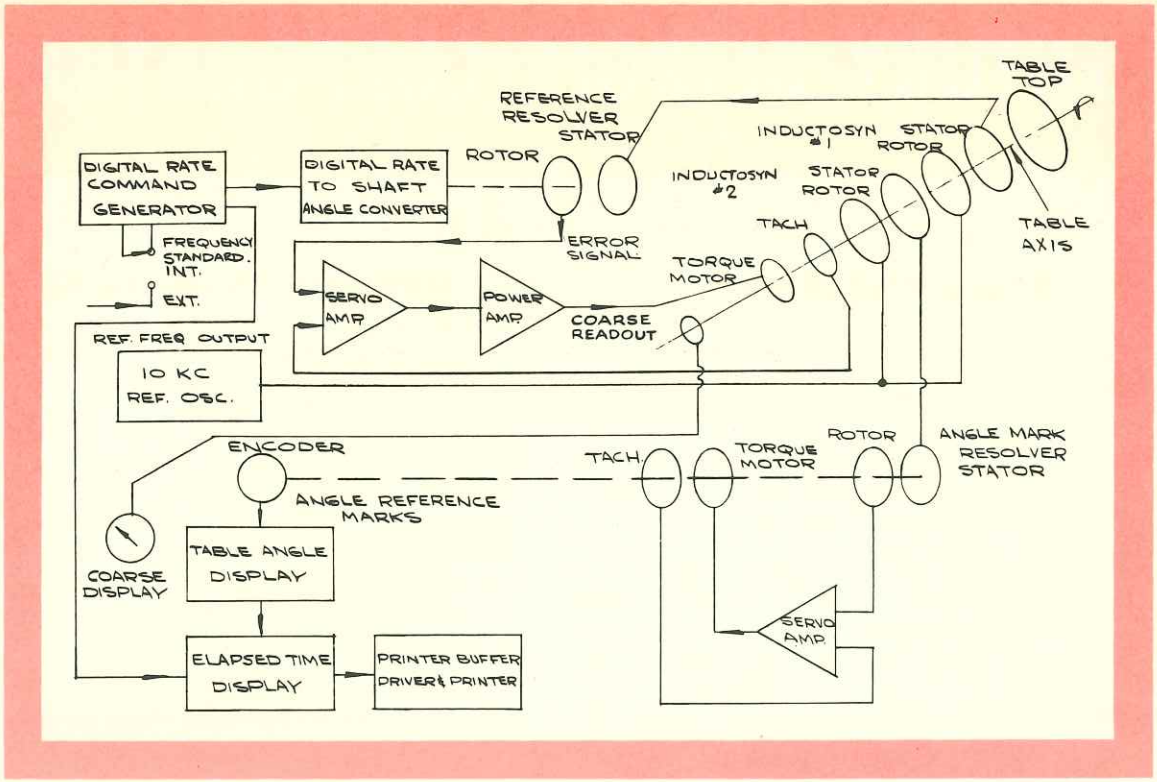
An axial gear drives such single-speed components as the resolver, a coarse synchro transmitter, etc. The components are mounted on the stationary shaft housing.

100 slip rings are standard, but special packages or a servoed slip ring system are also available as optional accessories.

HYDRAULIC POWER UNIT

A conventional reservoir, with motor-driven pump, balanced-piston relief valve, and nitrogen charged accumulator supplies hydraulic fluid for the bearing. Suction and output filtering to a clarity of 10 micron rms. are provided. Oil cooling is done by a water-cooled heat exchanger, if satisfactory cooling water is available, or by a refrigeration unit if it is not.

Pressure monitoring switches, filter indicator switches and visual gages are provided for safety interlocking. The electric control panel is integral with the hydraulic unit.



BLOCK DIAGRAM OF ELECTRONIC RATE DRIVE AND READOUT SYSTEM

TABLE ANGLE COMMAND SYSTEM

A train of sine waves from either an internal oscillator (with drift of 10^{-8} or less parts per day) or an external frequency standard is converted to pulses and counted down to an appropriate rate. (Thumbwheel switches can be provided for selection of multiples of the basic rate, if desired.) A logic network converts the pulse train to a form and to a power level suitable to drive a small Slo-Syn motor. This provides an electrical gear ratio of 200 pulses per revolution. The Slo-Syn motor drives a sine-cosine pot whose output, suitably amplified, drives another Slo-Syn in a synchronous mode. The Slo-Syn being a 100-pole motor, makes one revolution for each 50 of the pot. The second Slo-Syn drives the reference resolver.

The rotor of the Table Tracking Inductosyn is excited by a 10 kc signal. The stator, which is connected like a resolver, then picks up components whose phase and amplitude describe the position of the stator with respect to the rotor. However, since the plate pattern of the Inductosyn is a repetitive one, it produces a full electrical cycle every degree of rotation. Therefore, if the reference resolver is controlled so as to produce a full turn every degree (about every 4 minutes at 1× earth rate), the table can, by the circuit shown above, be servoed to null the difference between reference angle and actual table angle. No mechanical gearing whatever is required.

SERVO AND POWER AMPLIFIERS

Conventional ac error amplification raises the resolver rotor signal to a usable level. It is then phase-detected, and subjected to dc amplification in an operational amplifier. Networks providing a wide range of stabilizing signals are driven by this amplifier, and a rate signal from the tachometer is summed with the output of the networks in a second stage. The output, which is still in dc form, is amplified to a suitable power level for the torque motor in a linear power amplifier. Output current is displayed on a panel meter and is brought out to a connector for recording, if desired. All test points are available on the front panel.

ANGLE MARK GENERATOR

A second Inductosyn on the table axis serves as a reference for the angle increment marks. The rotor is excited by a 10 kc oscillator. The stator output is then a pair of sine waves whose phase and amplitude indicate electrical output angle, having a periodicity of 1° because of the Inductosyn plate pattern. The stator drives the stator of a follow-up resolver, whose rotor output is thus the follow-up error signal. This is then amplified, demodulated, and amplified in a dc mode, at which time it is shaped and summed with the tachometer signal to provide an extremely tight loop. The combined signal is power-amplified and drives the dc follow-up torque motor. Because of the very high gain and slow speed of the system, very little angular inaccuracy is introduced.

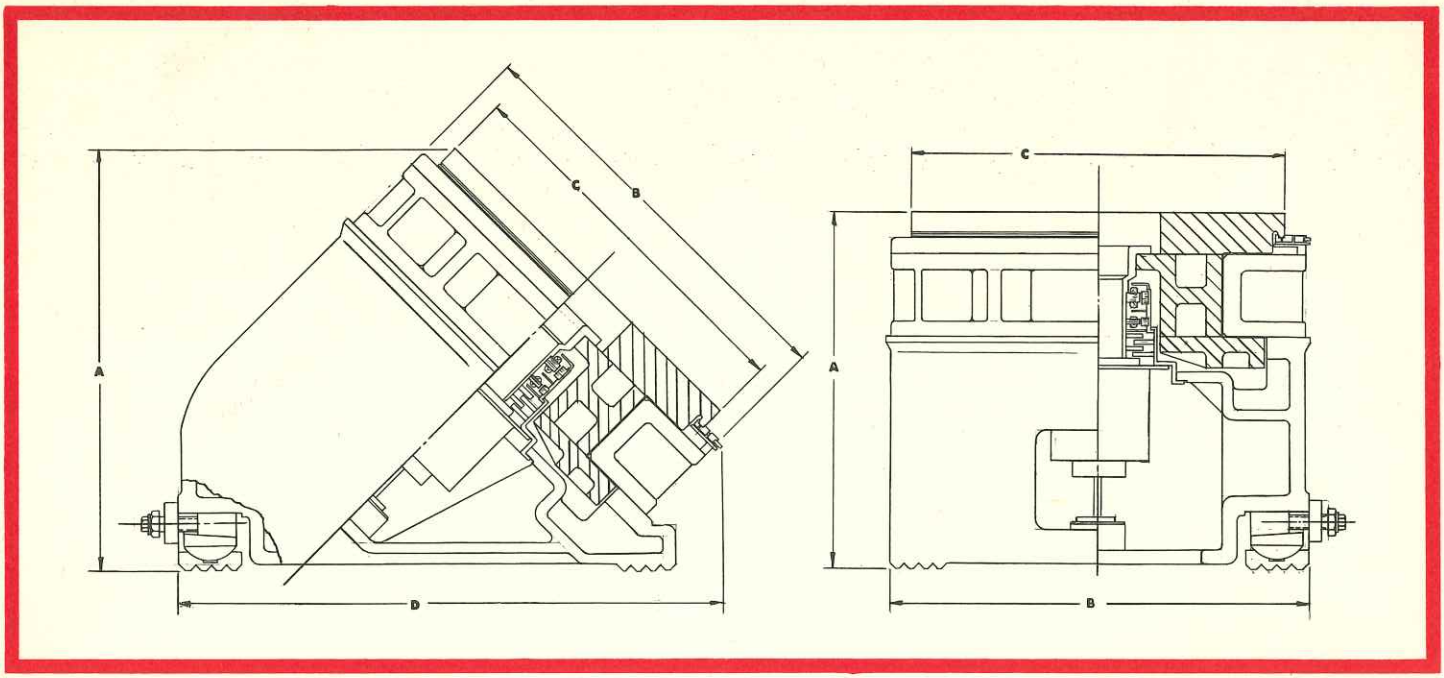
The torque motor also drives a Baldwin encoder, which serves to produce angle marks at a preset interval, and with great accuracy. The drive system and output buffering to adapt the encoder to the display units (below) is also supplied in this chassis.

READOUT SYSTEM

The readout modules are our standard line of gyro table auxiliaries, which are covered thoroughly in other brochures. They include an Incremental Table Angle Display, and Elapsed Time Display, and a Printer Buffer, Driver and Printer unit.

By means of these modules, the change in table angle since the start of testing and the most recent elapsed time for an angle increment are displayed on Nixie tubes, and the printer prints a continuous 7-digit record of both of these quantities.

A panel with gross function controls, coarse position synchro display and similar information is provided.



POLAR ORIENTED TABLES **VERTICALLY ORIENTED TABLES**

SPECIFICATIONS

Orientation and Model No. (**-latitude angle)	Letter Dimension	Vertical CD-V48-L	Polar CD-P48**-L	Vertical CD-V32-L	Polar CD-P32**-L
Overall Length — in.	D	—	72-78	—	48-52
†Overall Height — in.	A	51	60-72	34	40-48
Bearing Housing Diameter — in.	B	60	60	40	40
Std. Platen Diameter — in.	C	55	55	37	37
Max. Platen Diameter — in.	—	72	72	48	48
Hydraulic Power Unit Dimensions — in.	—	24W x 50L x 50H	24W x 50L x 50H	24W x 50L x 32H	24W x 50L x 32H
System Weight — lb.	—	22,000	26,000	8,000	10,000
‡Load Capacity — lb.	—	20,000	8,000 @ 24"	10,000	4,000 @ 18"
Planar Wobble — sec.	—	± 0.2	± 0.3	± 0.2	± 0.3
Axial Eccentricity — in. TIR	—	0.000025	0.000030	0.000025	0.000030
Std. Torque Motor — ft.-lb.	—	35	35	22	22
Std. Range Available — ft.-lb.	—	25-300	25-300	11-35	11-35
Slip Rings — Std.	—	140	140	100	100
Slip Rings — Max.	—	300	300	250	250

†Height depends on latitude angle.

**Latitude angle is specified to nearest integer value. Range of adjustment of leveling is ± ½° from this value.

Static friction of the axis on any table is negligible compared to that of slip rings and torque motor.

All units are interlocked to prevent operation of drive in case of hydraulic failure, filter clogged, clamp operated, or excess oil temperature.

‡System accuracies are guaranteed even with the appalling payloads listed, as long as they are balanced.

Measured results of stability of axis orientations on tables of this type indicate shifts of less than ± 1 sec. over 1000 hr. periods.

HYDROSTATIC & AEROSTATIC C-D BEARINGS

CENTURY-DETROIT

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